Mini-laparoscopy in urology

Needlescopic surgery is here (again) to stay

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Global adaptation and widespread use of minimally invasive procedures in all aspects of urological surgery demonstrate a constantly increasing interest in reducing perioperative morbidity in urology.

Since the first laparoscopic nephrectomy performed in 1990 by Clayman et al, laparoscopic urologic surgery has been well established as the standard of care for the majority of major urological operations demonstrating lower blood loss, reduced perioperative pain and shorter hospitalization than open surgery[1]. In addition, the introduction of robotic assistance during the last decade reduced the steep learning curve of conventional laparoscopy and eliminated most of laparoscopic limitations including two-dimensional vision and reduced degrees of instrument freedom.

The latter explains the rapid adaptation of robotic assisted laparoscopy worldwide. Nevertheless, despite the reduction of abdominal wall injury, as opposed to open approaches, laparoscopic surgery still induces significant postoperative pain and carries a risk for bleeding, infection, and hernia formation at all points of instrument entry.

In an attempt to reduce even more the morbidity of conventional laparoscopy and to push postoperative cosmesis towards a totally scarless outcome, laparoendoscopic single site surgery (LESS) and natural orifice transluminal endoscopic surgery (NOTES) were developed. In the first case all instruments are inserted and the whole operation is carried out through a single (usually umbilical) abdominal incision. The second technique uses natural orifices (currently only vagina in urological clinical use) to host additional laparoscopic instruments or to facilitate specimen extraction. Several reports have documented the feasibility and safeness of both approaches[2]. In addition, LESS has been documented to have equivalent perioperative outcomes with conventional laparoscopy in numerous operations including nephrectomy (simple, radical, donor or partial), pyeloplasty, adrenalectomy, sacrocolpopexy and radical prostatectomy[3-7].

Although pioneering, both techniques are not widely adopted by urological community mainly due to several limitations associated with their use. LESS is limited by the lack of instrument triangulation leading to inferior ergonomy, instrument classing, in-line instrument view and troublesome suturing or lateral tissue retraction. Transvaginal assisted surgery is associated with unfamiliar working angles, a long distance to upper track and a gender specific application of the approach. As a result of these drawbacks, the feasibility and safeness of LESS and NOTES or even their equivalence with conventional laparoscopy seem not enough to deserve the adding difficulties for the surgeon unless their superiority against the well established conventional laparoscopy is proven with certainty.

The impact of LESS and NOTES

Until robust data on LESS and NOTES outcomes are available, both techniques should be performed by experienced surgeons in an experimental setting[8]. Nevertheless, the above-mentioned techniques, despite being still under evaluation, already have a significant impact on the laparoscopic community. Their introduction established that perioperative morbidity of laparoscopy can and should be further reduced and that cosmetic outcome matters for both patients and surgeons. In other words, the most important contribution of single-port surgery and NOTES is the motive for even less morbidity, better cosmesis and constant development of advanced instruments.

Indeed, upon introduction of LESS and NOTES several new and refined instruments became available to surgeons to provide some ease in these demanding procedures and overcome most of the presented technical drawbacks. Multi lumen ports, flexible or pre-bent (curved) instruments and angled or flexible cameras provide the necessary triangulation for LESS, while extra-long laparoscopic instruments allow a wide range of upper track tissue manipulation by the transvaginal access. In addition, hybrid techniques, including a single site incision combined with additional mini-laparoscopic instruments, were developed[9]. This new application of miniaturized laparoscopic instruments, formerly used only for paediatric laparoscopic surgery, refocused medical industry on mini-laparoscopy and provided surgeons with second generation mini-laparoscopic instrumentation which demonstrate superior performance. With the availability of refined mini-laparoscopic instruments and following the trend of further improving laparoscopic morbidity, mini-laparoscopy has recently gained significant popularity[10].

Mini-laparoscopy

Mini-laparoscopic surgery is an old concept of surgery that utilises miniaturised (also termed needlescopic) 2-4 mm laparoscopic instruments for the accomplishment of conventional laparoscopic procedures. Initial reports on mini-laparoscopy (entailing 4mm cameras) can be traced back in early 1980's[11,12]. Nevertheless, the procedure was not applied in adult urologic surgery until recently. The main reason for the latter was that initial mini-laparoscopic instruments were problematic. Pure vision, loose grasping, defective irrigation or suction and decrease instrument durability were the main instrument limitations. Second generation mini-laparoscopic instruments have addressed the former drawbacks and currently, a wide range of needlescopic instruments have been added in the armamentarium of laparoscopic surgeons[13].

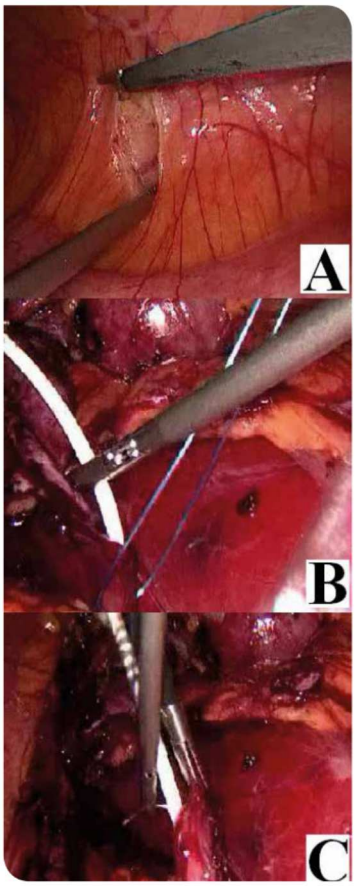

Figure 1: Needlescopic surgery follows the same principles with conventional laparoscopy. A: Told's line dissection. B: Ureteral stent insertion during pyeloplasty. C: Ureteropelvic anastomosis during pyeloplasty.

Figure 2: Common mini-laparoscopic setup during transperitoneal pyeloplasty. A 5mm transumbilical trocar hosting a 5mm 30o camera and two 3mm working ports.

The main advance offered by the use of needlescopic instruments is the reduction of abdominal wall trauma. The latter not only benefits postoperative cosmetic outcome (2-4mm skin incisions result in minimal post-operative scarring) but most importantly eradicate the risk for postoperative hernia formation and potentially cause less postoperative pain and faster rehabilitation. An additional advantage of this technology is that upon adaptation there is no need for a new learning curve as mini-laparoscopy maintains the principle of instrument triangulation and resembles conventional laparoscopic experience [Figure 1].

The ideal indication for mini-laparoscopy is any procedure that does not require specimen extraction. Currently, pure mini-laparoscopy in adult urologic patients has been applied only in case of pyeloplasty [Figure 2]. Pini et al reported preliminary results from a mini-laparoscopic pyeloplasty approach using a small-incision access retroperitoneoscopic technique (SMART). Using one 6-mm skin incision (for a 5-mm 30° telescope) and two 3.5-mm trocars (for 3-mm working instruments) authors documented comparable perioperative outcomes with conventional retroperitoneoscopic technique in addition to a superior cosmetic result[14]. Similarly, transperitoneal mini-laparoscopic pyeloplasty has been shown to offer better cosmesis and patient satisfaction than conventional laparoscopy[15,16].

In the case of mini-laparoscopic operations necessitating specimen extraction (eg nephrectomy) at least one of the initial incisions will be expanded at the end of the operation. Consequently one of the incisions (most commonly the umbilical) can host larger ports from the beginning increasing the available instrumentation (eg larger optics, staplers, coagulating devices etc)[17]. In this setting, needlescopic-assisted LESS (multiport trocar combined with one 3mm instrument) can provide the necessary triangulation missing in pure LESS, assist in suturing or demanding coagulative procedures without compromising the relative scarless cosmetic outcome of LESS [Figure 3][9]. In the setting of needlescopic-assisted NOTES, the whole procedure is being carried out via mini-laparoscopy and the vagina can be used for specimen delivery without the need for expansion of an abdominal incision[18].

Future prospects

It should be stressed that mini-laparoscopy is a field constantly expanding in non- urological specialties as well. Mini-laparoscopic cholecystectomy either pure or combined by transvaginal specimen extraction is under clinical evaluation in general surgery[19-21]. In addition, mini-laparoscopy rectal resection followed by specimen extraction through rectum has been shown to be feasible and safe, leading to a totally scareless outcome[22]. Mini-laparoscopic hysterectomy, diagnostic laparoscopy, pain mapping and ovarian biopsy have also been described in gynaecology[18,23-25]. Urology has much to gain out of this experience as well.

Future prospects of this technology could be micro-laparoscopy and robotic-assisted mini-laparoscopy. Technological advancements made possible to further miniaturise laparoscopic instruments to < 2 mm introducing micro-laparoscopy as a new field in minimally invasive approaches to surgery. Promising results in the diagnostic evaluation of the pelvis via microlaparoscopy have already been documented[26]. In addition, although current clinically applied robotic technology requires > 8 mm ports, novel mini-robotic instruments are under development and are expected to combine the reduced invasiveness of mini-laparoscopy with the well documented benefits of robotic assistance in the future.

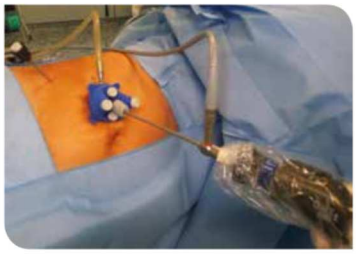

Figure 3: The introduction of an additional 3mm port during LESS provides the necessary instrument triangulation to increase ergonomy without compromising the final cosmetic outcome.

A step forward

Following the transition from open to laparoscopic surgery, mini-laparoscopy presents a step forward towards even less invasive procedures. Whether this technology represents the most we can get from minimally invasive surgery, or if there is still way to go, remains to be seen.

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